Active Humidity Control & Continuous Ventilation For Improved Air Quality In Schools

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Premise

- Investigation into the impact of active humidity control & continuous ventilation on school IAQ
- Targeting desiccant-cooling technologies
- Helping to meet US DOE goal of improving energy efficiency and to dispel belief that desiccant dehumidification systems are too costly

Project Objectives

1. Measure the importance of humidity control & continuous ventilation
2. Develop baseline IAQ data for schools in hot & humid climates
3. Provide data & recommendations for HVAC designs for improved schools IAQ
4. Document role of desiccant technologies to actively control humidity in schools
5. Provide data for school systems to specify the use of desiccant technology

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Project Team

Georgia Tech Research Institute

- Charlene Bayer (PI)
- Bob Hendry (sampling)
- Amy Cook (analytical analysis)
- Chris Downing (mechanical engineer – energy efficiency)

Georgia State University

- Sidney Crow (Microbiologist)
- Stephanie Hagen (Microbiological sampling & analysis)

Semco Inc.

- John Fischer (mechanical engineer – desiccant systems consultant & energy efficiency)

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Two Phases

- **Phase 1**
  - 10 Schools Investigation
- **Phase 2**
  - One School Intervention Investigation

Phase 1: Technical Approach

1. **Literature review of school IAQ**
2. **Field investigation of IAQ in 10 non-complaint Georgia schools**

   a. Matched pairs of schools with conventional HVAC systems and schools with desiccant cooling HVAC systems
   b. Continuous monitors placed in each school for CO_2, temperature, and relative humidity for approximately one year
   c. Diffusion VOC samplers in classrooms continuously for one year, changed approximately every 30 days.
   d. Active samples collected four to six times

Active Monitoring Parameters

1. VOCs
2. Particles
3. Bioaerosols
4. Aldehydes & ketones
5. CO_2
6. CO
7. NO_2
8. Temperature
9. Relative humidity
10. Air change rate

Continuous Monitoring

Continuous monitor placed in breathing zone in one classroom of each school measuring temperature, relative humidity, and CO_2

Diffusion tubes for VOCs placed in the breathing zone in one classroom in each school & changed approximately every 30 days.

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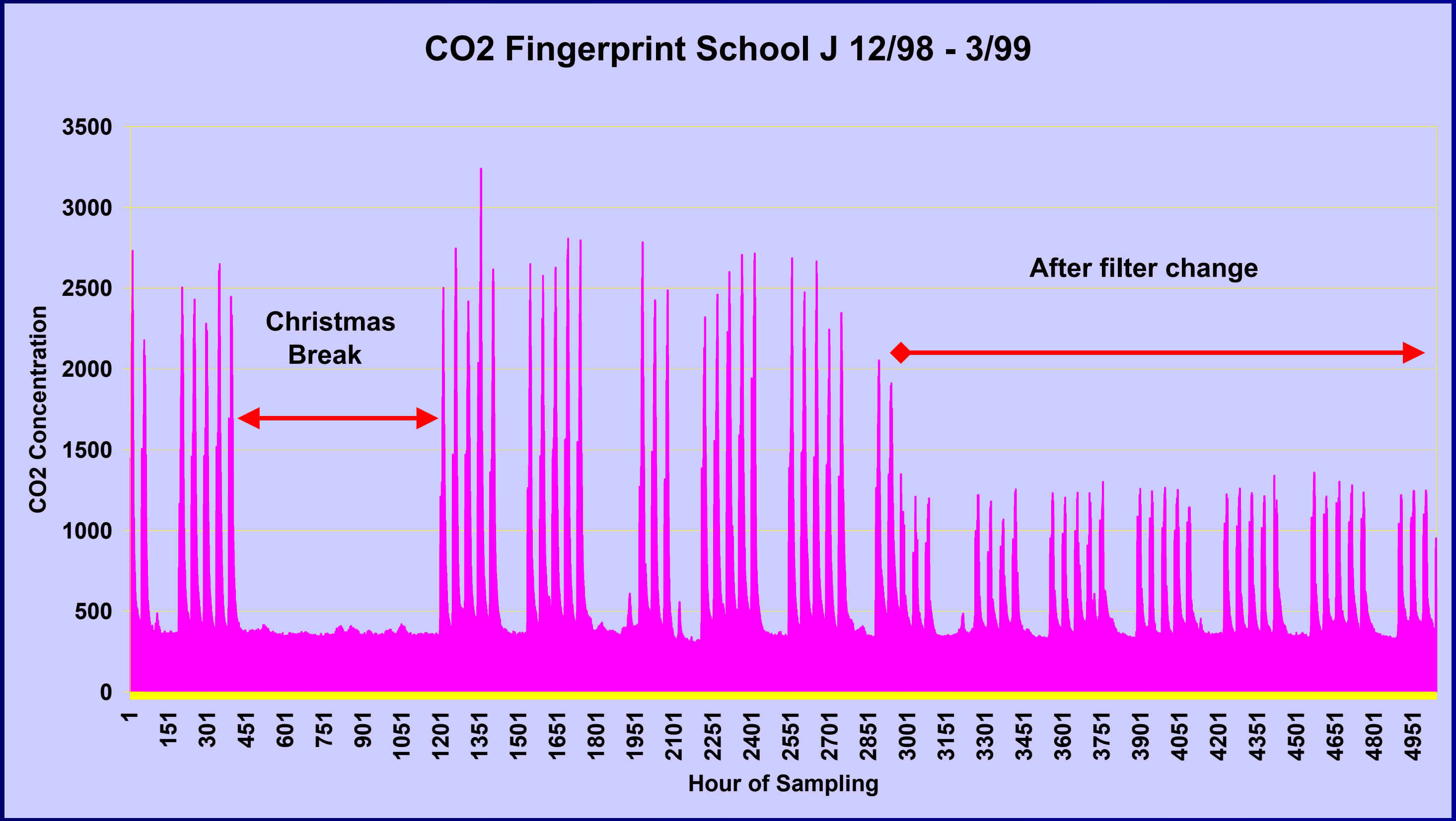
HVAC System Diagram

- Four different designs studied
  - **Outdoor Air & Exhaust Ducted Directly into Space**
  - **Outdoor Air & Exhaust Ducted to Heat Pump Return Duct**
  - **Outdoor Air Ducted to Heat Pumps, No Exhaust Air Path**
  - **Outdoor Air & Exhaust Ducted to Common Return Plenum**

System Design Effects Operation & Maintenance

Outdoor Air & Exhaust Ducted to Common Return Plenum



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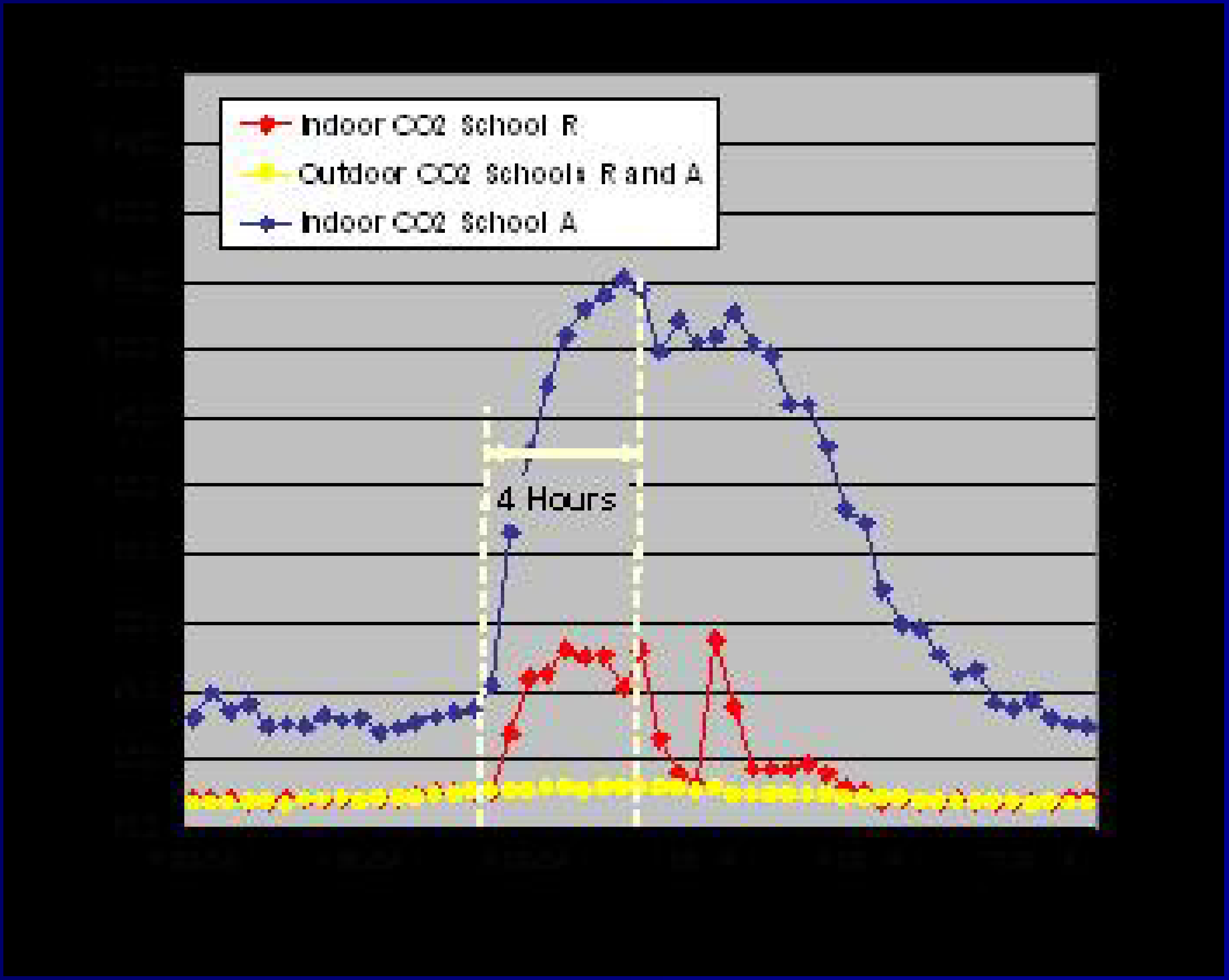
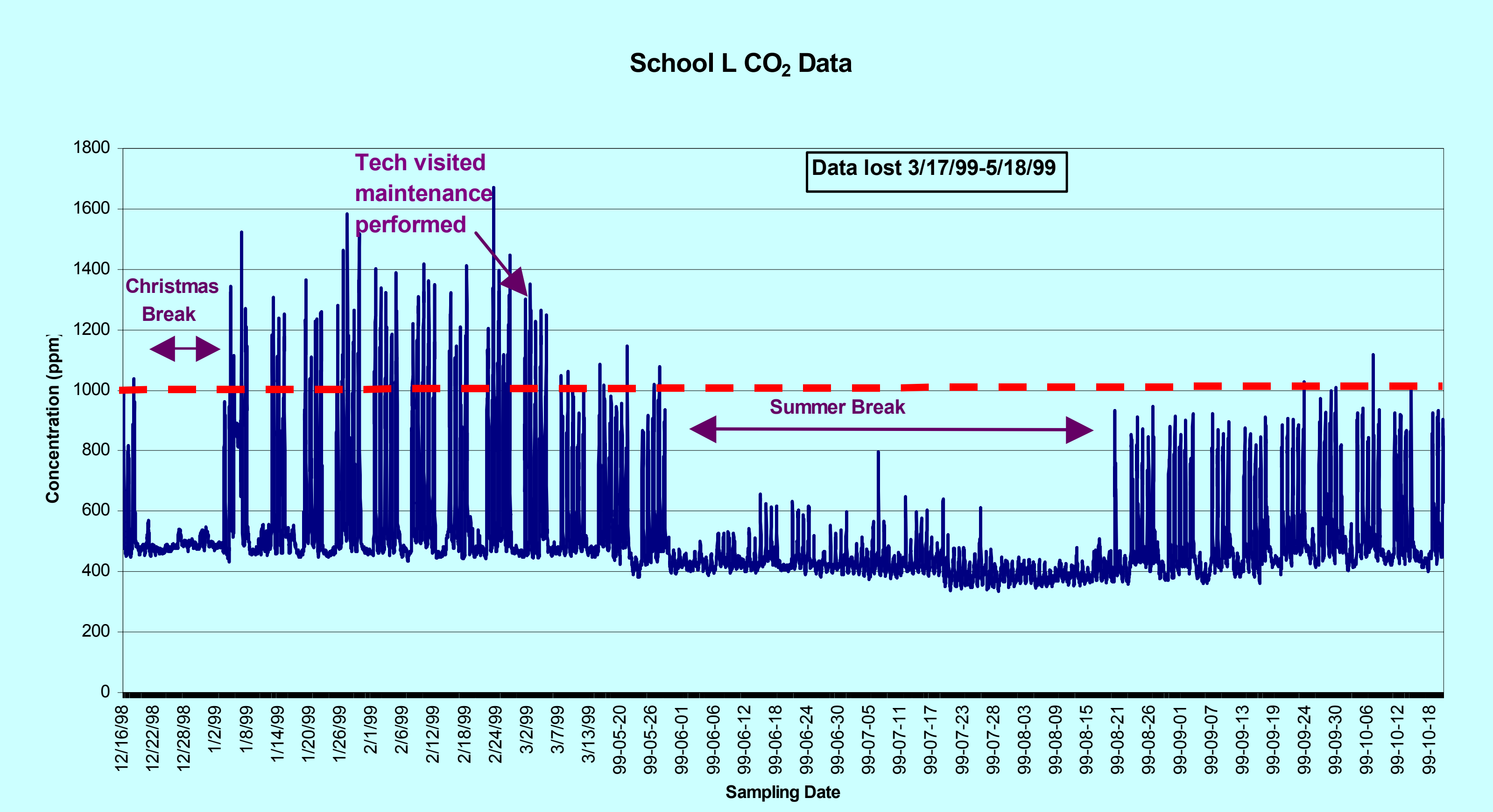
CO_2 Comparison



CO_2 With & Without Desiccant Operating



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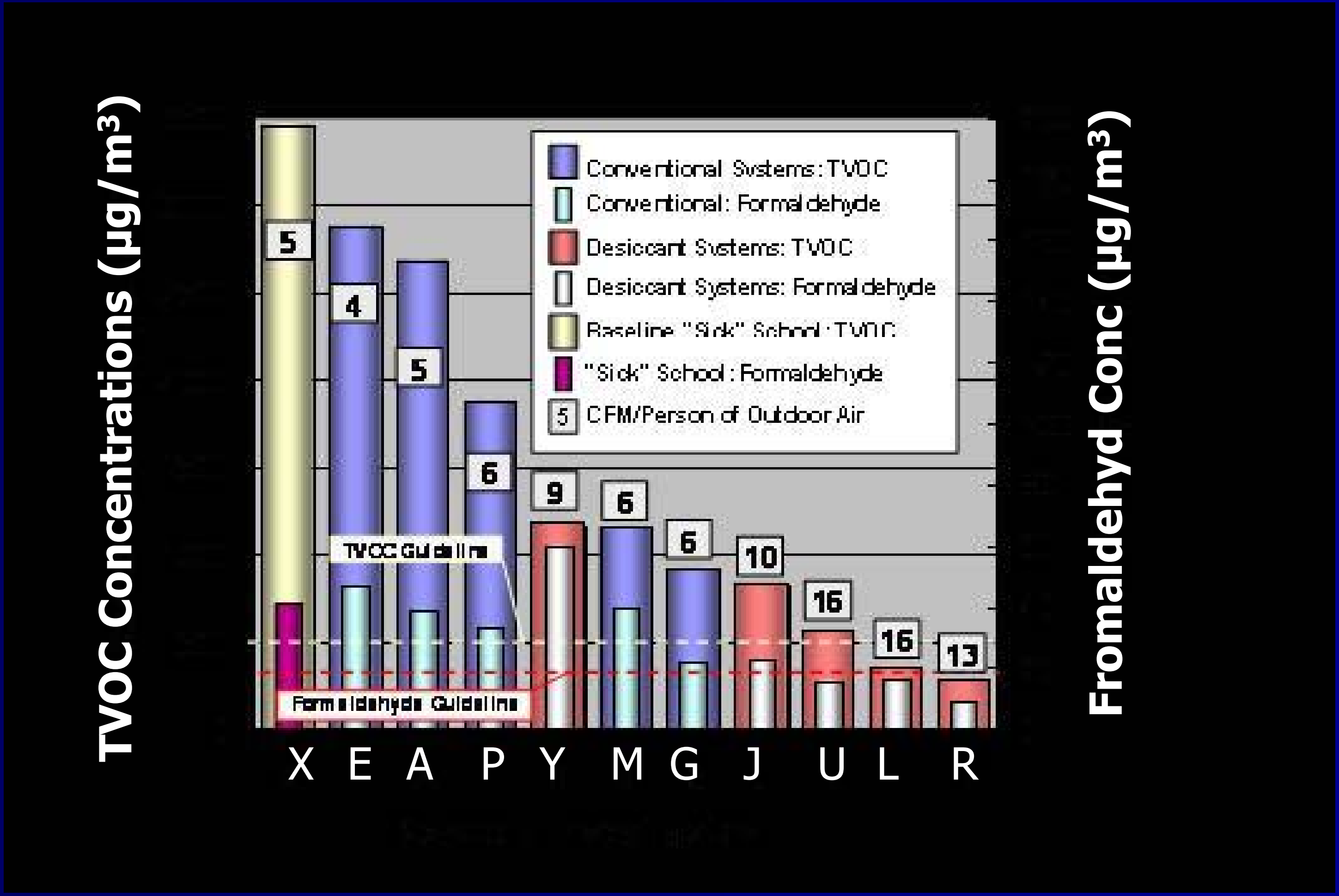
Contaminant Level Comparisons



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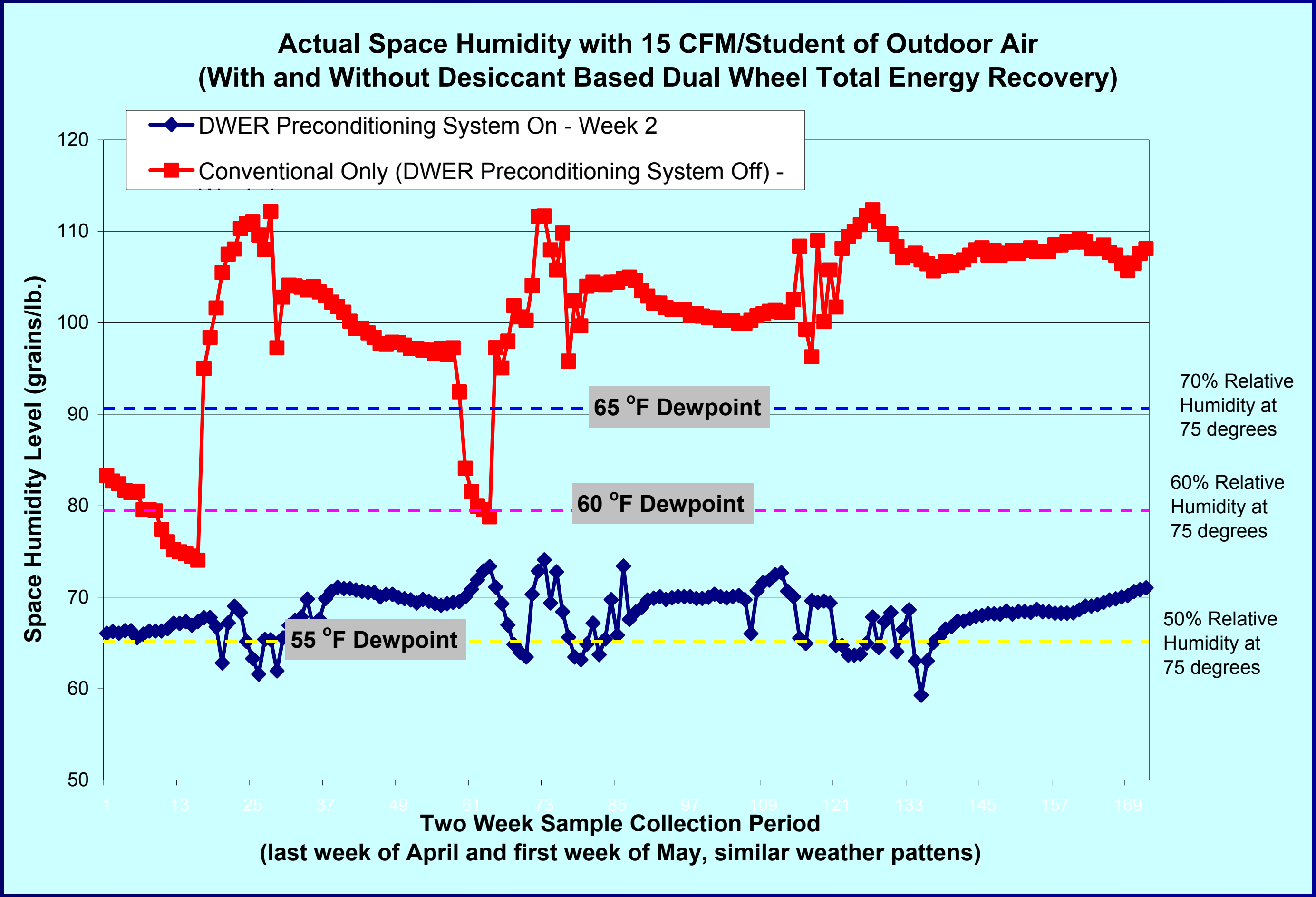
Space Humidity with & without Desiccant



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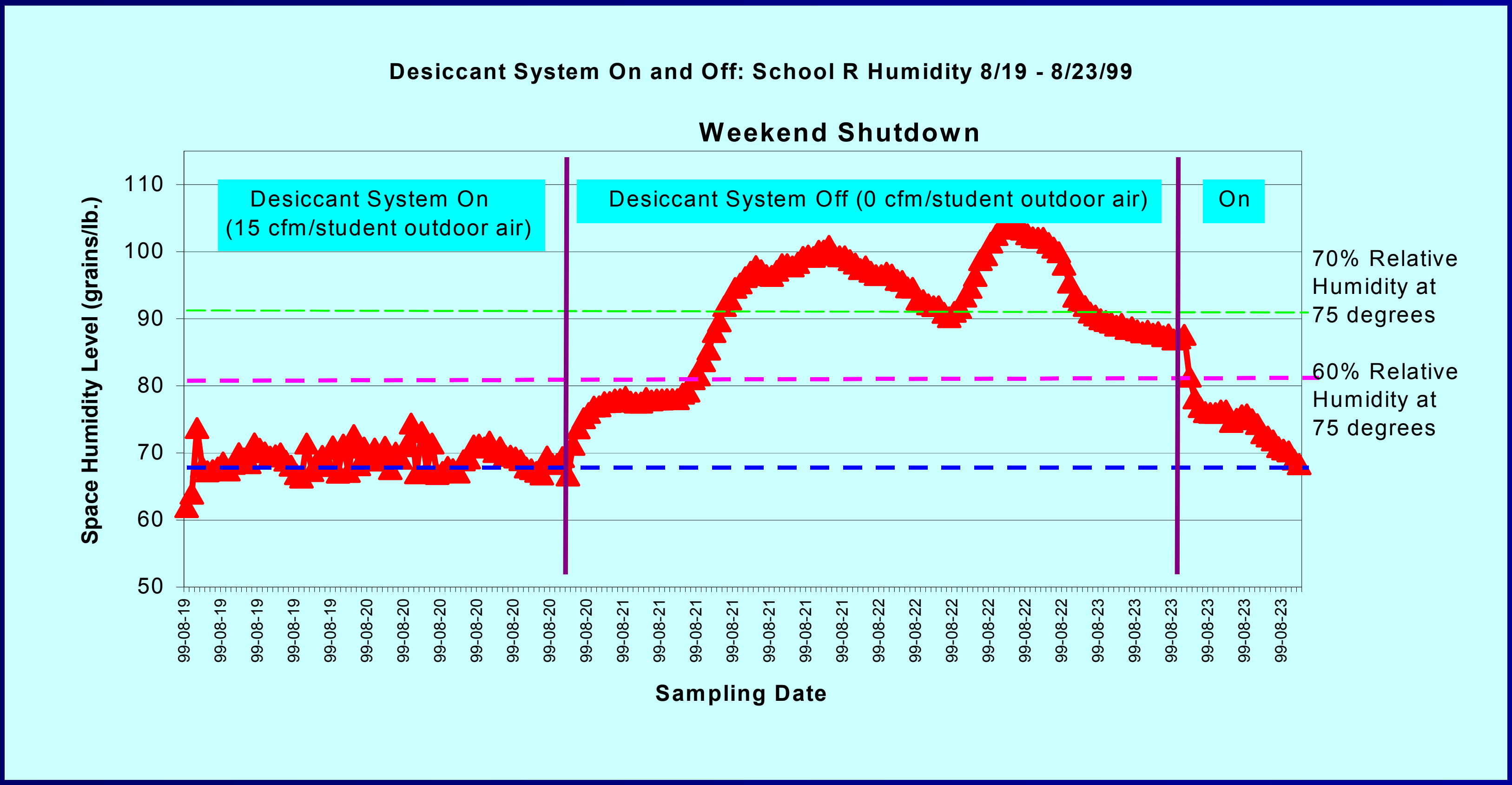
Effect of Weekend Shutdown



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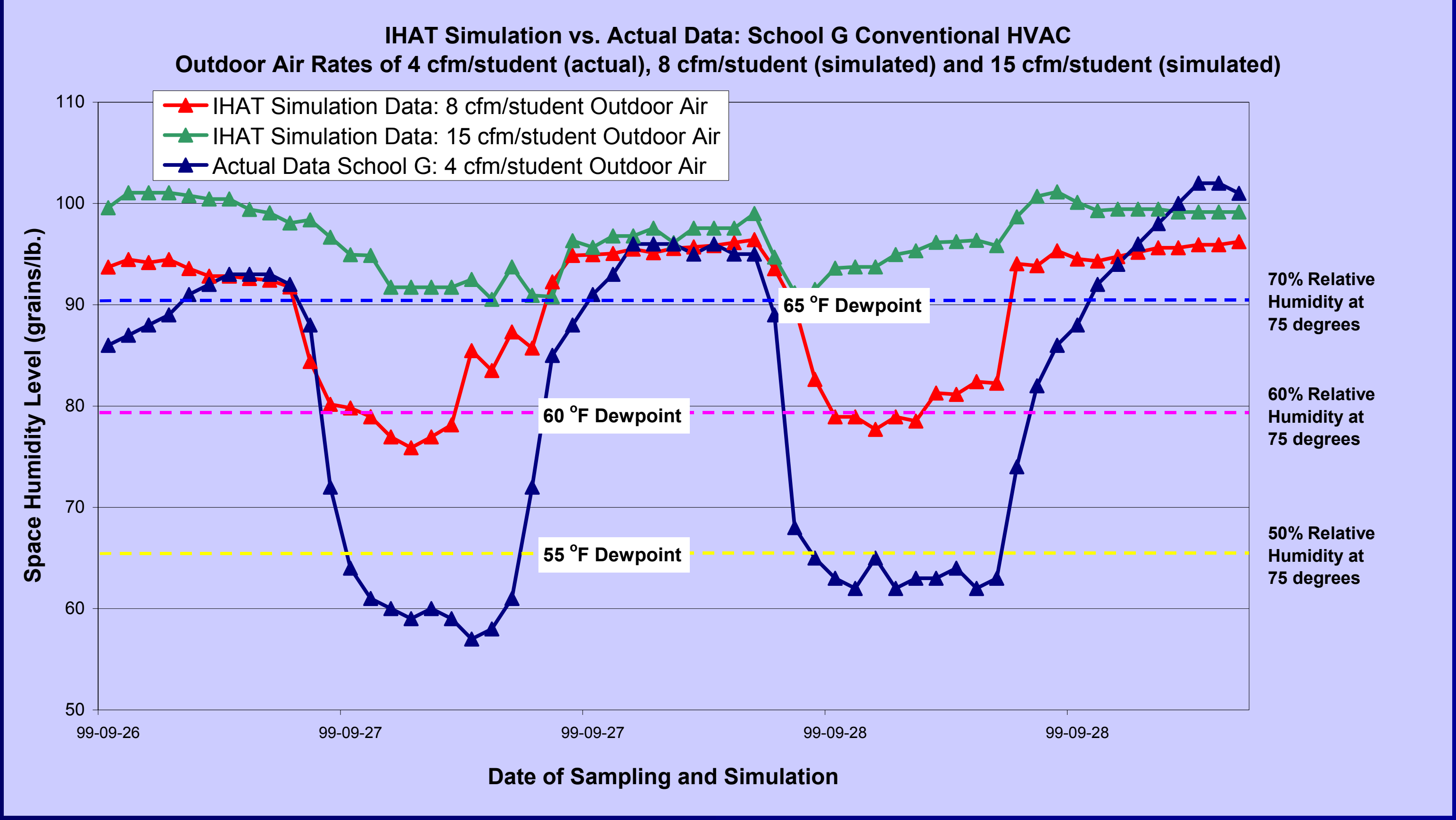
Humidity Level vs Ventilation Rate Modeling



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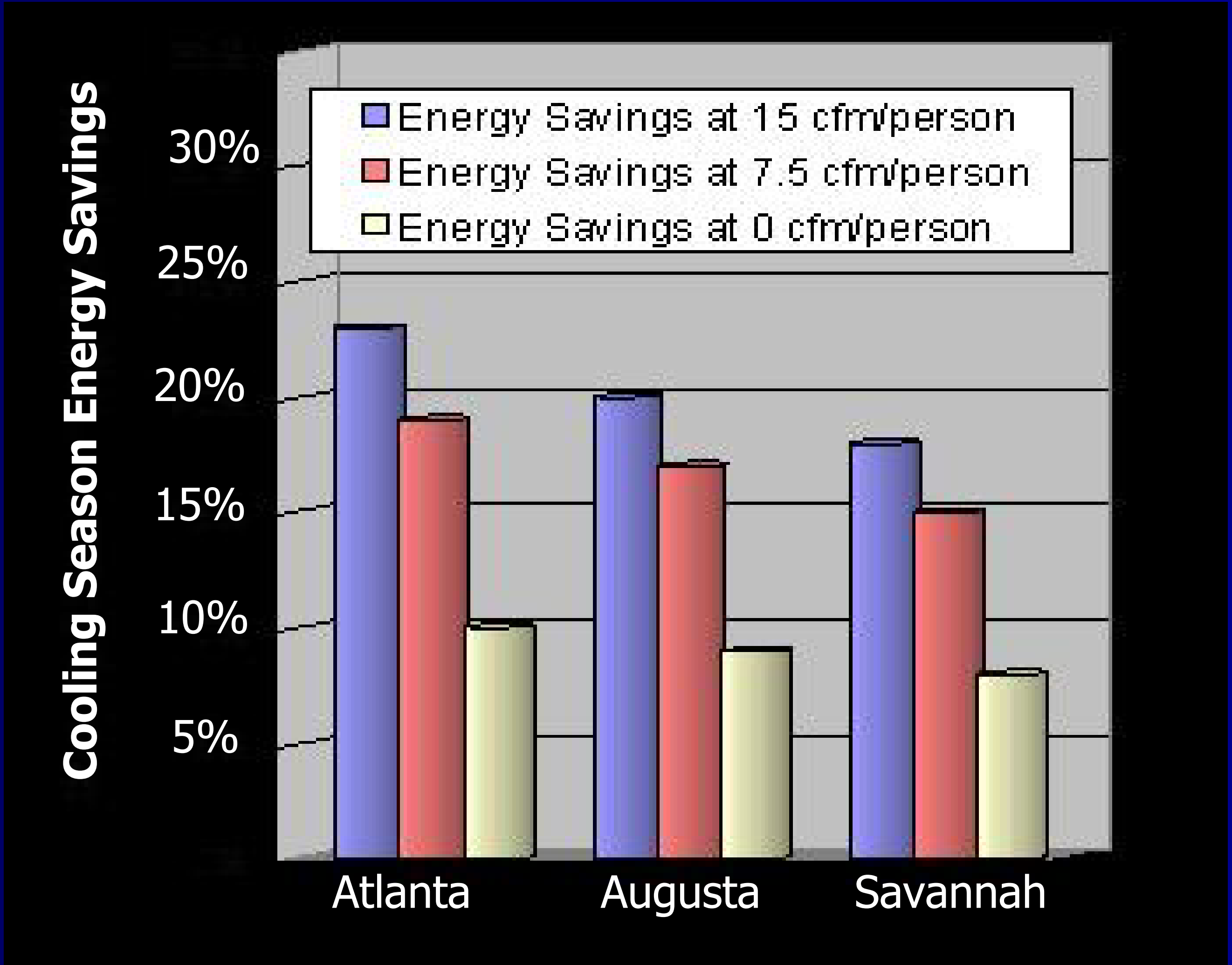
Modeled Energy Savings From 2°C Rise



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Student Absenteeism Data

- Absenteeism data showed trend in improved school attendance
- Larger population study necessary for statistical confirmation

School	Percent Absent											
	Nov98	Dec98	Jan99	Feb99	Mar99	Apr99	May99	Aug99	Sep99	Oct99	Nov99	Avg
A	5.30	6.00	6.90	6.90	7.30	7.30	7.80	4.20	4.20	5.60	5.60	6.10
J	3.60	4.10	4.90	4.90	4.80	4.80	4.80	2.80	2.80	3.70	3.70	4.08
E	4.24	2.20	4.05	6.11	5.72							4.46
R	3.19	2.46	2.55	4.80	4.31							3.46
L	5.39	5.70	7.92	6.57		6.26	6.75		3.48			6.01
P	4.85	3.17	6.35	6.66	6.04				1.29			4.73
G	2.76	2.89	3.49	3.65		3.81	3.55					3.36
U	3.91	4.61	4.67	3.30	3.35	4.17	4.92	2.07	2.46	3.06	3.15	3.61

Important Findings

- **Project Goals Met**
  - ✓ Measured importance of humidity control & ventilation on school indoor air quality
  - ✓ Developed baseline of indoor air quality data for schools in hot & humid climates
  - ✓ Provided data & recommendations for more energy efficient HVAC designs for improving indoor air quality in schools
  - ✓ Documented role of desiccant technologies to actively control humidity in schools
  - ✓ Provided data for school systems to justify specification of desiccant systems

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Important Findings

- Found statistical significance of the importance of adequate ventilation demonstrates the importance of HVAC system design integrating desiccant cooling systems with conventional HVAC system components
- Demonstrated the importance of design for the integration of desiccant systems with conventional HVAC system components
- Demonstrated the importance of training for building specifiers & contractors and for facility maintenance staff on the purpose and operation & maintenance of desiccant technologies

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Phase II: Technical Approach

- School with identified excess humidity and student/teacher health problems
- School designed in "pods" so that control and test areas available in same school
- County school board and school administrators agreeable to using school as research site

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Phase II: Technical Approach

- Desiccant system to be installed on one pod of school
- Ductwork and VAV boxes to be replaced and upgraded
- Testing to be conducted before, immediately after, and six months after desiccant system installation

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Phase II: Technical Approach

- At request of school and school system, all testing to be continuous monitoring (with the exception of microbial testing, which was performed after the school hours)
- Continuous monitors for temperature and relative humidity in 8 pod classrooms and 1 control classroom
- Continuous monitors for CO_2 in 4 pod classrooms and 1 control classroom
- One-month diffusion time-weighted averaged VOC sampling tubes placed in the 4 pod classrooms and 1 control classroom
- Airborne microbial samples collected in 4 pod classrooms and 1 control classroom

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Phase II: Progress to Date

- Before intervention sampling conducted
  - Results still being analyzed

- Installation of ductwork, VAV, and desiccant system to be installed soon

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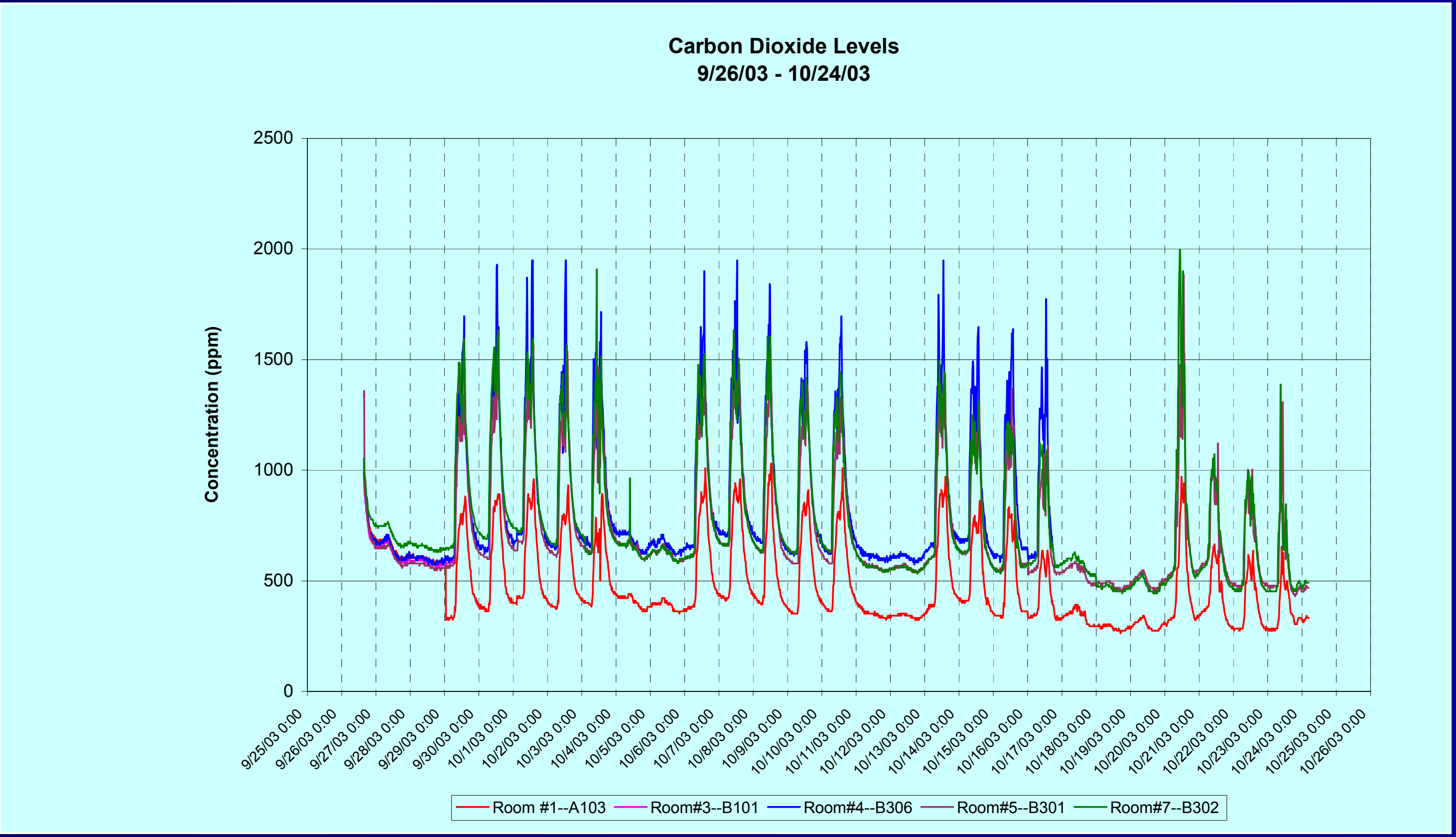
Phase II: CO_2 Data Before Installation



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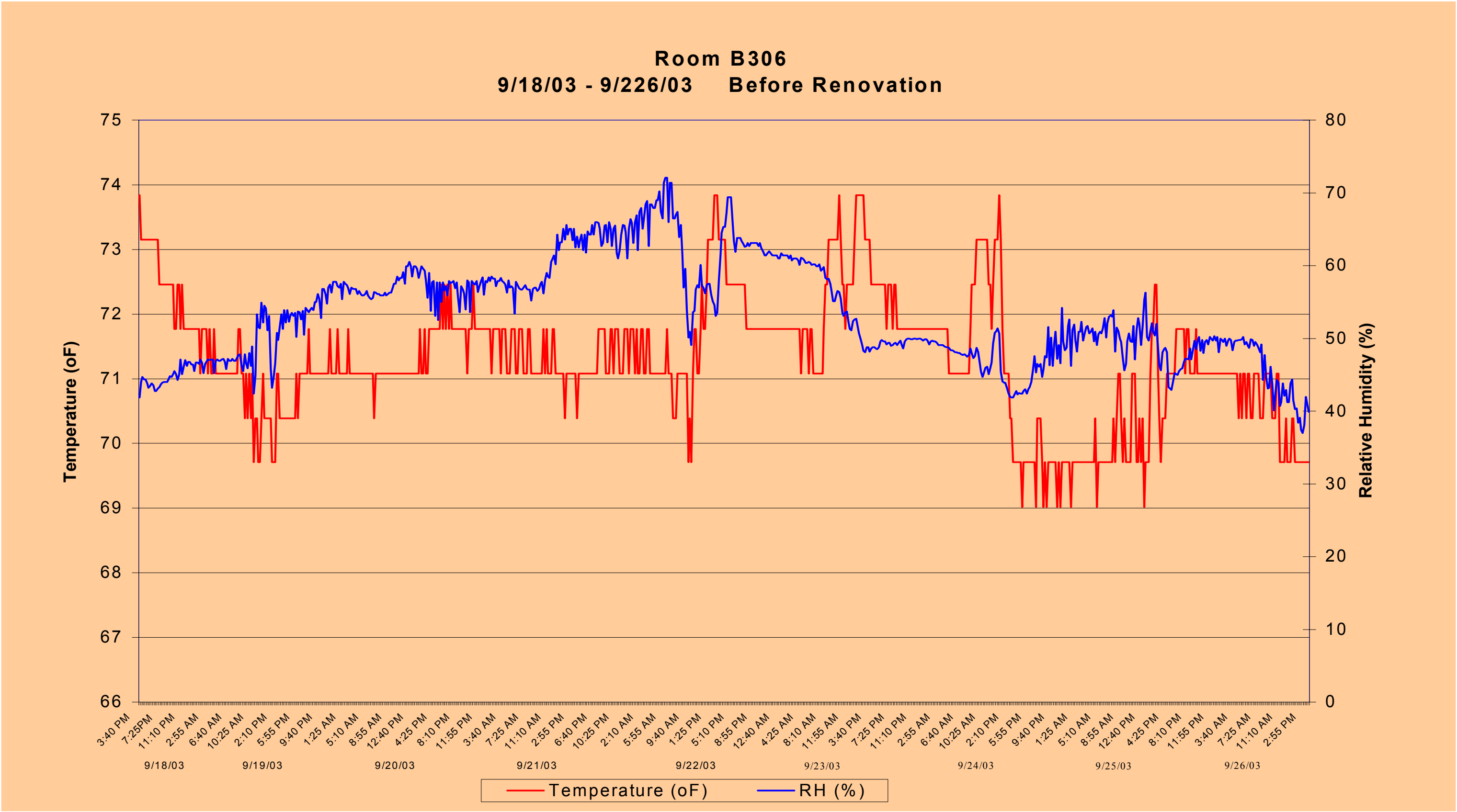
Phase II: Humidity Before Installation



Research Addresses School Multiple School Concerns

- First Equipment Costs
- New HVAC technology
- Operating Costs
- Operating Convenience
- Classroom HVAC Design
- Classroom Productivity
- Student/Teacher Health
- Operation & Maintenance Issues
- IAQ Indicators

Publications

- Literature Review
  www.ornl.gov/ORNL/BTC/iaq.pdf
- ASHRAE IAQ 2001
- International Conference on Indoor Air 2002
- Paper in ASHRAE Summer 2001 IAQ Newsletter
- Invited lead article in May 2003 *ASHRAE Journal*
- Other publications in progress

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Findings Dissemination

- Presentations at various school facility managers meetings
- Presentation at Texas Energy Conservation Group
- Interactions with various school facility managers
- Proposals prepared to develop IAQ management plans for San Antonio school systems
- Proposal to develop electronic media version of important findings and recommendations

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Future Research Needs

- Research to link IAQ improvements to increased learning and school attendance and health
- Research to investigate improvements in asthma incidence in schools related to optimized IAQ
- Additional research into intervention impacts on IAQ and energy efficiency in schools
- Research into energy usage and improved IAQ into combined co-generation and desiccant technology systems for schools

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